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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

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In the Matter of: **1998 Biennial Regulatory Review -- Amendment of Part 18 of the Commission's Rules to Update Regulations for RF Lighting Devices**	**ET Docket No. 98-42**

Motion to File Joint Supplemental Comments of Sirius Satellite Radio Inc. and XM Radio Inc.

By this motion, Sirius Satellite Radio Inc. ("Sirius") and XM Radio Inc. ("XM Radio") request, pursuant to Section 1.45(c) of the Federal Communications Commission's Rules,[1] that the Commission include the attached Joint Supplemental Comments in the above-captioned proceeding. The scope of the Joint Supplemental Comments is limited to the issues raised by the results of joint tests conducted by Sirius, XM Radio, and Fusion Lighting, Inc. ("Fusion") on November 3, 2000 and further tests conducted by Sirius and XM Radio on February 28, 2001. The tests quantified the effect that emissions from Fusion devices would have on satellite DARS receivers. Because the tests provided new data that is highly relevant to the Commission's consideration of proposed rules for the operation of high power lamps in the allocation for Industrial, Scientific, and Medical ("ISM") devices at 2450 MHz, Sirius and XM Radio request this

[1] "Additional pleadings may be filed only if specifically requested or authorized by the Commission." 47 C.F.R. § 1.45(c).

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opportunity to add highly-relevant additional information to the docket of this proceeding.

For the foregoing reasons, Sirius and XM Radio request that the Commission include in the record Sirius and XM Radio's Joint Supplemental Comments.

Respectfully submitted,

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Dated: May 4, 2001

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SUMMARY

The Notice of Proposed Rulemaking ("NPRM") that initiated the instant proceeding proposed to update the regulations for radio frequency ("RF") lighting devices to permit operation of certain high power lamps in the allocation for Industrial, Scientific, and Medical ("ISM") devices at 2450 MHz. Throughout this proceeding, the Federal Communications Commission ("FCC" or "Commission") has been concerned about the potential of such lights to interfere with the licensed operations of various FCC licensees, including Sirius Satellite Radio Inc. ("Sirius") and XM Radio Inc. ("XM Radio"), providers of satellite digital audio radio service ("satellite DARS") in the 2320-2345 MHz band. Accordingly, Sirius and XM Radio have sought rules to protect their operations from harmful interference from RF lights.

Throughout the Commission's consideration of proposed rules for RF lights at 2450 MHz, Sirius and XM Radio have submitted numerous comments, *ex parte* filings, and technical analyses that demonstrate the potential of RF lights to interfere with the reception of satellite DARS transmission by DARS consumer receivers. Testing recently undertaken by Sirius and XM Radio confirms that RF lighting devices will cause harmful interference to DARS receivers unless out-of-band emissions from RF lights are below 25 dBμV/m at three meters (18 μV/m at three meters). The tests, conducted at PC Test in Columbia, Maryland on November 3, 2001 and on a Fusion lighting system installed at the Department of Energy ("DOE") building in Washington, DC on February 28, 2001, show that Fusion is manufacturing lamps that exceed these out-of-band emissions levels and that such lamps will impose serious harmful interference to DARS receivers, preventing consumers from receiving DARS transmissions.

To ensure the successful deployment of DARS as a consumer service, the Commission must take immediate action to limit out-of-band emissions from RF lights. Accordingly, Sirius and XM Radio urge the Commission to: (i) adopt a specific rule to prevent Fusion and others from manufacturing and distributing RF lighting devices whose out-of-band emissions in the 2320-2345 MHz band exceed 25 dBμV/m at three meters (18 μV/m at three meters); (ii) eliminate non-compliant lights by December 31, 2001; and (iii) enforce existing FCC rules that prohibit unlicensed devices, including RF lights, from causing interference to licensed operations.

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Joint Supplemental Comments of Sirius Satellite Radio Inc. and XM Radio Inc.

I. Introduction

The Notice of Proposed Rulemaking ("NPRM") that initiated the instant proceeding proposed to update the regulations for radio frequency ("RF") lighting devices to permit operation of certain high power lamps in the allocation for Industrial, Scientific, and Medical ("ISM") devices at 2450 MHz.[1] In that NPRM, although the Federal Communications Commission ("FCC" or "Commission") stated that the purpose of the proceeding was "to support the introduction of new and beneficial products," it noted that it was concerned about possible out-of-band interference and sought to ensure that "spectrum-based communications services

[1] 1998 Biennial Regulatory Review - Amendment of Part 18 of the Commission's Rules to Update Regulations for RF Lighting Devices, ET Docket No. 98-42, FCC 98-53 (April 9, 1998) (Notice of Proposed Rulemaking ("NPRM")). A summary of the NPRM was put on public notice at Regulations for RF Lighting Devices, 63 Fed. Reg. 20362 (April 24, 1998) (proposed rule).

continue to be protected from interference."[2] Specifically, the FCC was "particularly concerned" that out-of-band emissions from RF lights operating at 2450 MHz "could cause interference to other services operating near the 2450 MHz band, such as the Digital Audio Radio Service operating in the 2320-2345 MHz frequency band."[3] In addition, the FCC has assumed that one of the most important uses of RF lights will be "outdoor lighting, such as street lighting,"[4] and Fusion Lighting, Inc. ("Fusion")—the principal proponent of 2.4 GHz lights—has confirmed to the FCC that it considers outdoor applications to be a "large market for its products."[5]

Throughout the Commission's consideration of proposed rules for the operation of a new generation of RF lighting devices in the ISM allocation at 2450 MHz, Sirius Satellite Radio Inc. ("Sirius") and XM Radio Inc. ("XM Radio") have argued that radiated out-of-band emissions from such lights could interfere with their licensed operations.[6] Indeed, Sirius already submitted

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[2] NPRM at 1.

[3] *Id.* ¶ 12.

[4] *Id.* ¶ 13.

[5] *See Ex Parte Filing of Fusion Lighting, Inc.* in ET Docket 98-42 (in response to June 29, 2000 *Ex* Parte filing of XM Radio Inc.) (filed July 26, 2000).

[6] *See, e.g., Comments of Satellite CD Radio, Inc.*, ET Docket No. 98-42 (filed July 8, 1998); *Comments of American Mobile Radio Corporation*, ET Docket No. 98-42 (filed July 8, 1998); *Reply Comments of Satellite CD Radio, Inc.*, ET Docket No. 98-42 (filed Aug. 24, 1998); *Reply Comments of American Mobile Radio Corporation*, ET Docket No, 98-42 (filed Aug. 7, 1998); *Ex Parte Filing of Sirius Satellite Radio Inc., ET Docket No. 98-42* (filed May 25, 2000); *Ex Parte Presentation in ET Docket No. 98-42* (June 14, 2000); *Ex Parte Presentations in ET Docket No. 98-42* (filed June 23, 2000); *Ex Parte Presentation in ET Docket No. 98-42* (filed Sept. 5, 2000; Oct. 18, 2000); *Ex Parte Filing of Sirius Satellite Radio Inc. in ET Docket No. 98-42* (filed Dec. 5, 2000).

technical studies that demonstrate the potential of RF lights to interfere with reception of satellite digital audio radio service ("satellite DARS") transmission by DARS consumer receivers.[7]

At the FCC's request, Fusion, Sirius, and XM Radio undertook joint tests on November 3, 2000 at PC Test in Columbia, Maryland to quantify the effect that emissions from Fusion devices would have on satellite DARS receivers. Then, on February 28, 2001, in order to obtain data from a Fusion installation that is actually in place, Sirius and XM Radio took RF emission measurements on the Fusion lighting system installed at the U.S. Department of Energy ("DOE") building in Washington, DC. The results of this testing are described fully in the attached Technical Analysis[8] and are summarized below.

The conclusion to be drawn from these tests is plain: out-of-band emission levels in the satellite DARS band from Fusion lights will cause harmful interference to the operations of Sirius and XM Radio, and if these devices are allowed to proliferate, they will imperil the promise of satellite DARS and the interests of the radio listening public. This result would also undermine licensing satellite DARS by auction, at which Sirius and XM Radio paid approximately $170 million to the U.S. government for the right to use spectrum in the 2320-2345 MHz range.

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[7] *See* Sirius Satellite Radio Inc., "Analysis of Interference from RF Lighting Devices into Sirius Satellite Terrestrial Receivers May 24, 2000," ET Docket 98-42 (filed May 25, 2000) (*ex parte*) ("*May 2000 Study*"); *Ex Parte Filing of Sirius Satellite Radio Inc. in ET Docket No. 98-42* (filed Dec. 5, 2000).

[8] *See* Sirius Satellite Radio Inc. and XM Radio Inc., "Summary and Tests of RF Lighting Devices and the Interference Caused to Satellite DARS Receivers Performed on November 3, 2000 and February 28, 2001," April 12, 2001 (concurrently filed with and appended to this submission) ("*Technical Analysis*").

Under the Communications Act of 1934 and the Commission's Rules, Fusion's ISM lighting devices may only operate on a secondary, non-interference basis vis-a-vis the licensed operations of Sirius and XM Radio. This is all the more true when considering *out-of-band* emissions by Part 18 devices, *i.e.*, emissions into bands other than those authorized for "non-communications" uses, such as RF lighting. As a result, the Commission can authorize RF lighting in the 2450 MHz band only if it can be shown not to cause interference to other services.

Accordingly, as discussed below and in the attached *Technical Analysis*, the FCC should promptly adopt rules that prevent Fusion and others from marketing interfering RF lighting systems. To this end, the FCC should adopt a rule that requires out-of-band emissions from RF lights operating at 2450 MHz to be lower than the DARS receive satellite signals. Because satellite DARS receivers are very sensitive, an interference to noise density ratio ("I/N") from all sources of interference of -6 dB is appropriate.[9] In order to protect DARS receivers to this I/N ratio, the FCC must adopt an out-of-band field strength limit of 25 dBμV/m at three meters (which is equivalent to 18 μV/m at three meters) for RF lights and other Part 18 ISM devices operating in the 2.4 GHz band.[10]

Sirius and XM Radio understand better out-of-band performance may be accomplished through some combination of filtering, shielding and more RF "quiet" power supply,[11] and that

[9] As noted in the May 2000 Study, the International Telecommunication Union ("ITU") generally uses an AT/T of 6 percent (equivalent to an I/N ratio of -12.2 dB) as the threshold for interference for individual entries. *See May 2000 Study* at 5.

[10] *See Technical Analysis* at 3.

[11] A comparison of various Fusion models demonstrates that Fusion achieving better out-of-band performance: (1) is technically possible (*i.e.*, the DOE installation has a direct current switching

(Continued...)

Fusion can decrease out-of-band emissions below levels emitted by the DOE installation. As manufacturers of equipment whose use of the 2.4 GHz spectrum is secondary to use of that spectrum by licensed users, Fusion and other makers of RF lights should be required to bear the full cost of any re-engineering that is necessary to prevent their operations from interfering with satellite DARS. Any other action would permit a non-licensed service to impose harmful interference on a licensed service.

II. Legal Standard

The Communications Act of 1934 directs the Commission "to maintain the control of the United States over all the channels of radio transmission"[12] and to "make reasonable regulations...governing the interference potential of devices which in their operation are capable of emitting radio frequency energy by radiation, conduction, or other means in sufficient degree to cause harmful interference to radio communications."[13] The FCC incorporated this mandate into Part 18 of its rules, which contains particular limits for out-of-band emissions for ISM equipment and imposes a general obligation that such devices not interfere with the operations of licensed services. Specifically, Section 18.305 of the rules sets forth out-of-band field strength limits for ISM devices.[14] However, these emission limits are not "safe harbors" for ISM

(...Continued)
power supply that greatly reduces out-of-band emissions without reducing their luminous capability); and (2) is not necessarily costly (*i.e.*, it may be achieved through some combination of filtering, shielding, and changes in power supply).

[12] 47 U.S.C. § 301 (1994).

[13] 47 U.S.C. § 302a(a) (1994). *See also* 47 C.F.R. § 18.101 (2000) (FCC has authority "to prevent harmful interference to authorized radio communication services").

operations, and compliance with them does not alone demonstrate compliance. Rather, these limits represent the Commission's best prediction—made in advance and without specific knowledge of characteristics of ISM devices that might later be developed—of the limits necessary to protect the operations of adjacent licensed services.

Other provisions in Part 18 make clear that adherence to the stated out-of-band emission limits is just one aspect of compliance with the Commission's Rules. For example, Section 18.109 of the Commission's Rules requires that "ISM equipment be designed and constructed ... with sufficient shielding and filtering to provide adequate suppression" of out-of-band emissions.[15]

Section 18.111 takes this obligation even further such that "irrespective of whether the equipment otherwise complies with the rules in this part, the operator of ISM equipment that causes harmful interference to any authorized radio service *shall promptly take whatever steps may be necessary to eliminate the interference*."[16] Thus, the Commission's stated out-of-band emissions limits are not dispositive evidence of compliance with the law, and adherence to those limits does not permit unlicensed devices to impose harmful interference on primary services. Rather, even if equipment complies with the limits stated in Section 18.305 of the Commission's Rules, manufacturers of ISM devices must cease operations or modify their equipment in the event that their operations interfere with the operations of licensed services. This may require

(...Continued)

[14] 47 C.F.R. §§ 18.305(b) and (c) (2000).

[15] 47 C.F.R. § 18.109 (2000).

[16] 47 C.F.R. § 18.111(b)(2000) (emphasis added). *See also* 47 C.F.R. § 18.115(a) (2000).

ISM manufacturers to add filtering or shielding before or even after device is marketed, a well-known potential consequence of operating on a non-interference basis.

Fusion's RF lights are classified as ISM devices, and, therefore, their use of spectrum is secondary to licensed uses, including satellite DARS operations. As explained below, because Sirius and XM Radio now have definitive evidence that Fusion's operations in the 2450 MHz band threaten to impair their ability to deliver innovative, digital-quality programming to U.S. consumers, they respectfully request that the Commission promptly adopt rules that require Fusion, at its own cost, to re-engineer its lights. Although sufficiently protecting satellite DARS receivers from out-of-band emissions from RF lights may require Fusion and other makers of RF lights to replace the magnetrons and power supplies in the models they intend to deploy, Sirius and XM Radio are willing to accept other less-costly redesign solutions, such as additional filtering, *provided that* such changes reduce out-of-band emissions from RF lights below 25 dBμV/m at three meters, *i.e.*, 18 μV/m at three meters.

III. The Joint Fusion/Sirius/XM Radio Tests Reveal That Fusion's Operations Will Impermissibly Interfere With Satellite DARS Service

A. Fusion's Out-Of-Band Emissions Are Above FCC Limits, Suggesting That The FCC Should Clarify That Such Devices Be Measured With A Broad Video Bandwidth

The tests reveal that Fusion's lights, when measured using an appropriate test setup, violate or barely meet the Commission's existing Part 18 out-of-band emission limits. Figure 2 in the attached Technical Analysis shows the measured emissions of seven Fusion lights.[17] Three

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[17] *See Technical Analysis* at 3.

of these lamps exceeded the FCC limit on out-of-band emissions for "general" types of ISM devices, *i.e.*, $25*\sqrt{(power/watts)}$ at 300 meters, which, for a 1000 watt lamp measured at three meters, is approximately 70 dBμV/m.[18] Indeed, the worst case exceeded the FCC standard by more than 10 dB. The Fusion lamps tested and their measured emissions are provided in the table below:

Lamp Serial Number	1227	587	563	006	005	004	DOE
Field Strength at 3 m (dBμV/m)	84	78	69	65	59	77	52
FCC Limit at 3 m (dBμV/m)	70	70	70	70	70	70	70
dB Above FCC Limit at 3 m	13	8	-1	-5	-11	7	-18

Neither the Commission's April 1998 NPRM nor its June 1999 Report and Order[19] in this proceeding specifies a video bandwidth ("VBW") setting for measuring emissions from ISM devices. Similarly, FCC Measurement Procedure MP-5 specifies a resolution bandwidth ("RBW") for measuring emissions from ISM devices, but not a VBW.[20]

It is readily apparent from the test results that use of the broadest VBW, *i.e.*, 1 MHz, most accurately depicts the effects of out-of-band emissions from RF lights on satellite DARS receivers. As explained in the Technical Analysis, only a broader VBW properly takes into

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[18] *See id.*

[19] *See* 1998 Biennial Regulatory Review - Amendment of Part 18 of the Commission's Rules to Update Regulations for RF Lighting Devices, FCC 99-135 (June 16, 1999).

[20] *See* FCC Office of Science and Technology, *FCC Methods of Measurements of Radio Noise Emissions from Industrial, Scientific, and Medical Equipment*, FCC/OST MP-5 (Feb. 1986) ("MP-5") at § 2.2.2.

account the normal interference between two systems, especially where one is a high-powered system whose pulse characteristics are unknown.[21]

Second, based on the test assumption of the waveform characteristic, sweep rate, rise time and duration, measurements made at 1 MHz VBW were shown to convey more accurately the effects of Fusion out-of-band emissions on satellite DARS service delivery. The wide out-of-band emission bandwidth of RF lights observed in the tests shows that interference effects will be felt throughout the satellite DARS spectrum band.

Third, because Sirius receivers utilize 4 MHz of bandwidth and XM Radio receivers utilize 2 MHz, using a VBW of 30 kHz or 30 Hz for such wide bandwidth signals would inaccurately depict the interference effects of Fusion's out-of-band emissions on satellite DARS receivers. Therefore, it is appropriate to measure out-of-band emissions using the widest possible VBW.

In sum, the evidence suggests that some of Fusion's existing products exceed current Part 18 standards. In any event, regardless of the conclusion the agency draws about Fusion's conformity with existing rules, the FCC should clarify—either as codified in Part 18 or as a policy adopted in this docket—that ISM out-of-band interference should be measured with a VBW no narrower than 1 MHz (*i.e.*, peak).

B. Because Fusion's Signal Is Considerably Stronger Than The DARS Satellite Signal, DARS Receivers Will Receive Harmful Interference

The tests reveal that out-of-band energy from Fusion's lights, when measured in the satellite DARS band, 100 MHz away from the ISM band in which Fusion's lights are permitted

[21] *See Technical Analysis* at 5.

to operate, greatly exceeds the level of the DARS receive signal.[22] The Fusion emissions, thus, also exceed 25 dBμV/m at three meters (18 μV/m at 3 meters), the out-of-band emissions limit Sirius has urged the Commission to adopt in order to prevent significant degradation to the DARS receivers, as demonstrated in Sirius' *May 2000 Study*.[23] This is depicted graphically in Figure 2 of the Technical Analysis.

The powerful out-of-band emissions from Fusion will harmfully affect DARS receivers, rendering them incapable of picking up the considerably weaker receive signal from DARS satellites. As explained in the attached Technical Analysis, mitigating this interference requires Fusion either to install its RF lights far away from satellite DARS receivers—impossible if RF lights are deployed as street lighting—or to reduce out-of-band emissions so that DARS customers receive clear reception.[24] Ironically, satellite DARS customers will only be able to receive service if they are in close proximity to a terrestrial repeater—suggesting that if out-of-band emissions from Fusion's lights are allowed to be 25 dBμV/m at three meters (18 μV/m at 3 meters) or greater, Sirius and XM Radio would be forced to turn satellite DARS into a terrestrial network.[25]

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[22] *See Technical Analysis* at 4-5.

[23] *See May 2000 Study* at 14.

[24] *See Technical Analysis* at 7.

[25] Requiring satellite DARS licensees to employ additional terrestrial repeaters would be inefficient and costly. It also could inspire vigorous opposition from broadcasters and from wireless communications service ("WCS") and Multipoint Distribution Service ("MDS") licensees that must coordinate with satellite DARS repeaters.

Fusion lights installed along roadways illustrate the severity of the problem that satellite DARS customers will encounter. When travelling along roadways flanked by Fusion installations similar to the lamp with serial number 1227, out-of-band emissions from the light will be so great that the DARS receiver must be located 1800 meters from the light in order not to receive significant degradation. Although other Fusion models, such as Fusion's DOE installation, emit much lower levels of out-of-band energy, even these lamps must be located far from DARS receivers in order not to interfere with DARS reception. For example, the DOE lamp, the Fusion lamp with the lowest levels of out-of-band emission, must be installed approximately 63 meters[26] from a DARS receiver in order not to cause harmful interference to DARS transmissions.

No matter which Fusion light is deployed, because most streetlights are pointed straight down and are typically no more than 30 meters above the road, there is no way for passing cars to avoid the out-of-band emissions from Fusion lights. Consequently, out-of-band emissions from Fusion lights can be expected to cause long periods of interference as the vehicle traverses an area with a Fusion installation.

C. The Potential For Interference Is Not Eliminated By Off-Axis Attenuation

The test results make clear that Fusion's lights interfere with transmissions to satellite DARS receivers even at maximum levels of off-axis discrimination (*i.e.,* when DARS antennas are not directly in the path of the main beam of a Fusion light). To the extent that Fusion's lamps are employed as street lights—as both the FCC and Fusion expect—they will be pointed straight

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[26] *See Technical Analysis* at 6.

down. Vehicles with satellite DARS receivers will pass below and only a few feet from the focus of the Fusion lamp.[27] However, as explained in the Technical Analysis, typical emissions from an RF light mounted on a streetlight, pointed straight down, will only be attenuated by 9 dB off-axis, too little to mitigate the 45 dB advantage the interfering lights will have over DARS receivers.[28] This lack of off-axis discrimination ensures that *any* Fusion streetlight installation will cause harmful interference to satellite DARS.

IV. Implications of Test Results

The FCC may sanction unlicensed devices, including ISM equipment such as Fusion lighting, only where the agency has minimized any potential for harmful interference. The instant proceeding was begun, in part, to explore whether a new generation of RF lighting devices could use ISM spectrum near 2450 MHz without interfering with the operations of licensed services. Any new rules must fit within the current Part 18 framework, which requires that Part 18 devices operate on a secondary, non-interference basis vis-a-vis primary licensees (such as satellite DARS) "irrespective or whether the equipment otherwise complies"[29] with the Part 18 rules. The rules further require ISM manufacturers whose equipment causes harmful interference to licensed services to "promptly take whatever steps may be necessary to eliminate

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[27] As previously described, satellite DARS systems employ hemispherical antennas with low gain (3 dBi).

[28] *See Technical Analysis* at 10, Figures 4-5.

[29] 47 C.F.R. § 18.111(b) (2000).

the interference."[30] Logically, the agency proposed to investigate the question and adopt a clear prospective rule.

The record of this proceeding does not establish that the FCC can meet those goals. Rather, the results of the joint testing confirm that the current generation of Fusion lights causes harmful interference to the licensed operations of the satellite DARS providers. This is true even if Fusion's installations meet the Commission's stated out-of-band emissions limits for "any device" because, in general, the non-interference obligation supersedes the obligation to comply with a particular out-of-band emission limit.

The fact that some Fusion lamps may meet the levels in Section 18.305 does not imply that Fusion can lawfully use the 2.4 GHz band. Any other result would upend the fundamental concepts of primary and secondary allocations. If Fusion and other manufacturers of RF lights cannot design their products in a way that protects licensed services in adjacent bands, they cannot be permitted to continue to market these products as currently configured. The FCC simply cannot at this time lawfully authorize a technology that will undermine the licensed use of neighboring spectrum.

Under the Commission's Rules, manufacturers of RF lighting such as Fusion must bear all responsibility for design changes to reduce the interference its lights impose on the satellite DARS service.[31] As primary users of spectrum, neither consumers nor satellite DARS providers

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[30] *Id. See also* 47 C.F.R. § 18.115 (2000).

[31] This is particularly true given that Sirius and XM Radio paid approximately $170 million to the U.S. government for their use of this spectrum. In contrast, Fusion's lights may use spectrum only through sharing and on a secondary basis—at no charge. *See* 47 C.F.R. § 18.111(b).

share this burden. In any event, with Sirius' DARS systems already in orbit, XM Radio's system constructed with one spacecraft in orbit, and power limits imposed under international coordination agreements with Canada and Mexico, no further changes in satellite DARS receivers or satellites are warranted or possible.[32]

Although the November 3, 2000 joint tests and the February 28, 2001 tests on Fusion's DOE installation prove that Fusion's RF lights will interfere with the operations of the satellite DARS licensees, this result need not impair Fusion's business plans. Fusion has freely disclosed that it has already designed 2.4 GHz lighting that would suppress its out-of-band emissions by 36 dB with a 15 percent loss in efficiency, thereby significantly mitigating the harmful emissions from its lights. Although these lamps, including Fusion's DOE installation, do not fully protect DARS receivers, they demonstrate that out-of-band emissions can be greatly reduced by using direct current switching power supply.[33] Moreover, by use of specialized magnetrons, filtering, and other less costly methods, Fusion could further reduce out-of-band emissions from its lights without reducing their luminous capabilities.

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[32] As Sirius and XM Radio explained in their December 5, 2000 *ex parte* responses to Fusion's technical questions, the satellite DARS licensees have already taken all reasonable precautions to protect their receivers from strong out-of-band emissions. Those responses, which also were filed in this docket, show that Sirius and XM Radio DARS receivers use bandpass filtering in the first amplifier stage, which significantly attenuates out-of-band emissions. In addition, this amplifier has a very wide dynamic range and a high Third Order Intercept point. Accordingly, the satellite DARS licensees believe that they have done as much as possible to improve the satellite link margin and limit out-of-band emissions that fall into their band. *See Ex Parte Filing of Sirius Satellite Radio Inc. in ET Docket No. 98-42* (filed Dec. 5, 2000) (enclosing Sirius/XM Responses to Questions from Fusion Lighting, Inc.).

[33] *See Technical Analysis* at 10.

As noted above, however, it has not been shown that changing the magnetrons and the power supply is the only way to cure the interference RF lights cause to the satellite DARS service. Although the DARS licensees do not know of other, less costly solutions, devising such solutions is not the responsibility of Sirius and XM Radio, the FCC licensees whose use of the 2320-2345 MHz band is primary. Rather, Fusion and other manufacturers of ISM devices deployed at 2450 MHz must "promptly take whatever steps may be necessary to eliminate the interference" its devices inflict on the licensed operations of Sirius and XM Radio.[34]

V. Request for Relief

Sirius and XM Radio concur in the FCC's preliminary conclusion to permit RF lighting in the 2.4 GHz band. However, secondary use of the ISM band for RF lighting cannot cause unacceptable interference to licensed and primary services, including satellite DARS. Based on the results of testing conducted jointly by one RF lighting proponent and two satellite licensees, the lamps that Fusion currently intends to market cause harmful out-of-band interference to satellite DARS receptions, to the detriment of the listening public. As a matter of law and policy, the FCC cannot, and should not, authorize such interference.

In sum, the *Technical Analysis* confirms that RF lighting devices will cause harmful interference to DARS receivers unless emissions from RF lights are below 25 dBμV/m at three meters (18 μV/m at 3 meters). Therefore, in order to discharge its responsibility to manage the radio spectrum to minimize harmful interference, the FCC must:

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[34] *See* 47 C.F.R. § 18.111(b) (2000). *See also* 47 C.F.R. § 18.115 (2000).

1. Promptly amend Section 18.305 of its rules to provide that out-of-band field strength limits for RF lights operating in the 2.4 GHz band must be below 18 μV/m at 3 meters; and

2. Require that existing and already marketed RF lights operating in the 2.4 GHz band that do not comply with the limits imposed under Section 18.305 of the Commission's Rules be eliminated or replaced, prior to December 31, 2001, with redesigned lights whose out-of-band emissions are below 18 μV/m at 3 meters; and

3. Enforce existing FCC rules that prohibit unlicensed devices, including RF lights, from causing interference to licensed operations.

Respectfully submitted,

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Dated: May 4, 2001

A

Summary and Tests of RF Lighting Devices and the Interference Caused to Satellite DARS Receivers

Performed on November 3, 2000 and February 28, 2001

Study Date:
April 12, 2001

Sirius Satellite Radio Inc.
XM Radio Inc.

Introduction

This engineering report details efforts by representatives of Fusion Lighting, Sirius Radio and XM Radio to test Fusion Lighting products. In May of 2000, Sirius submitted a detailed analysis of the effects of RF lighting products on its satellite audio receivers.[1] This analysis demonstrated that unless RF lighting out-of-band (OOB) emissions were significantly attenuated from those predicted, Sirius satellite receivers would receive harmful interference.

On November 3, 2000, representatives from Fusion Lighting, Sirius Radio and XM Radio met for the purpose of evaluating the electromagnetic environments created by Fusion Lighting products. Laboratory measurements were conducted on several typical Fusion products in an effort better to quantify and understand the overall operating parameters of Fusion's RF lighting systems. Further testing was also performed on February 28th 2001 at a known Fusion Lighting installation at the Department of Energy in Washington, D.C. Observations during these sessions clearly support the May 2000 analysis that the out-of-band emissions emanating from RF lights will cause harmful interference to satellite Digital Audio Radio (satellite DARS) transmissions, and thus detrimentally impact performance and service delivery of the new digital satellite consumer radio service.

Fusion made available a list of data that it considered the results from the joint test. That list is attached hereto as Appendix A. Moreover, Sirius and XM supplemented the range of measurements with data taken near an existing and operating lamp known to have been designed and installed by Fusion.

Following its review of the technical analysis that follows, Fusion, through an April 19, 2001 email from its counsel to Sirius' counsel, informed Sirius that: "Fusion Lighting stands behind the test data contained in this report which is based on the results of joint testing that took place on November 3, 2001, but takes exception to the analysis and the conclusions drawn therefrom, as well as to any additional test data or materials contained in the report."

Overview of Testing

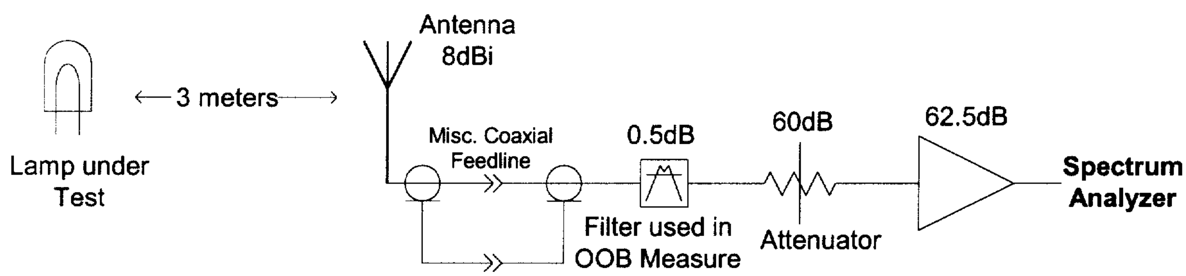
Test Setup. The initial testing of the Fusion lights was performed at PC Test, Columbia, MD. These tests included baseline calibration of the test range and measurements of radiated emissions for several lamps in several states. All measurements were performed with a 1 MHz Resolution Bandwidth (RBW), as specified by FCC Measurement Procedure MP-5. For the initial Main Beam emission measurement, a single lamp was measured utilizing a 1 MHz video bandwidth (VBW) setting. For OOB emission measurements, video bandwidth (VBW) settings of 30 Hz,

[1] *See Ex Parte* Filing of Sirius Satellite Radio Inc. in ET Docket No. 98-42, dated May 25, 2000.

30 kHz and 1 MHz were utilized to provide a variety of test sample measurements. In addition, radiated emission measurements were performed at 1 MHz VBW, at various angle offsets to obtain a radiation pattern. The FCC has not specified a required VBW setting.

The tests conducted by PC Test of Fusion light samples were in an anechoic chamber with measurements made at a distance of 3 meters from the sample. As can be seen in Figure 1, the simple block diagram below, the test receive antenna (with 8 dBi of gain) was followed by 60 dB of attenuation, a 62.5 dB gain low noise amplifier and associated cable loss.

Figure 1



In Band Test Measurements. To establish a benchmark of operation, initially a test of the in-band emissions was made. The initial RF product (s/n 1227) was positioned facing the antenna main beam. Once the 1000-watt Fusion lamp was illuminated, the unfiltered signal at 2450 MHz was measured for baseline 'in-band' calibration as 112.2 dBμV/m at 3 meters.[2] The FCC does not specify any in-band field strength limitation within the 2.4 GHz ISM band. Therefore, there is no standard for whether the RF power in band should be measured as a peak or average value.

Measured OOB Emissions. For the purposes of this test, however, the factor of interest was OOB emissions. The FCC rules do not currently contain a provision authorizing RF lighting at 2.4 GHz, and thus there is no standard for out of band emissions from RF lights near 2.4 GHz. General types of ISM devices (denominated as "any type") do have a limit on out of band emissions of 25*√(power/500 watts) at 300 meters which, for a 1000 watt lamp measured at three meters, is equivalent to approximately 70 dBμV/m.

To take a precise measurement of OOB emissions (due to the large in band signal level), it is necessary to filter out the main signal to make measurements of the out-of-band emission. A bandpass filter (K+L Microwave 80 MHz bandwidth) was

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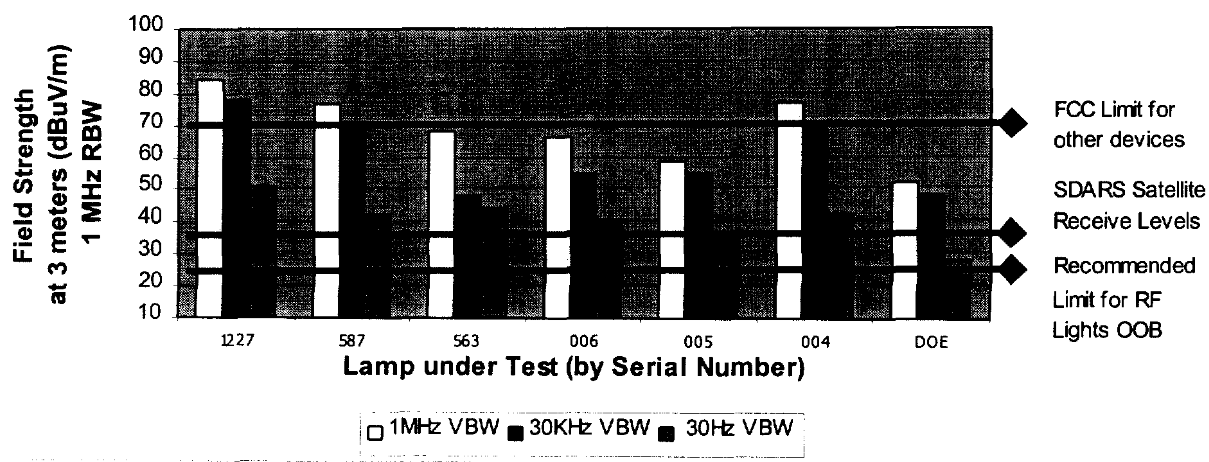
[2] The measured -22.8dBm at 3 meters, converted to dBμV per meter as follows:
(-22.8 dBm + 107) + 28 Antenna Factor yields: 112.2dBμV/m.

added and set to pass 2270 thru 2360 MHz at approximately ½ dB insertion loss, eliminating the in band effects that otherwise might be measured.

In all cases, results derived employing a narrower video bandwidth (say 30 Hz VBW) data appeared—as sample time increased—to approach levels similar to results derived by employing a broader video bandwidth (say 1 MHz) data. This is due to the VBW filter bandwidth effectively "gating" the lamps pulsed radiated waveform. Had the actual nature of the pulse waveform been known (*i.e.*, pulse rate, duration, frequency distribution, etc.), other measurements in zero bandwidth span could have been - utilized to quantify the actual energy produced, including duration, peak and average values. Only once this energy has been properly characterized and quantified may an accurate impact assessment be made. Therefore, the measurements herein may not be direct representations of average and peak but are merely estimates.

Figure 2 below summarizes the signal levels received at both the Columbia Maryland test and the subsequent field measurements in downtown Washington. All field strength numbers in Figure 2 are referenced to 3 meters. The Figure's Y-axis shows various radiated power measurements of the seven various lamps listed on the Figure's X-axis. The three different color bars for each lamp represent measurements using three different possible video bandwidths. The three horizontal lines in Figure 2 are, (1) at the top, the limit on out-of-band emissions (converted into a 70 dBμV/m power) for Part 18 equipment falling within the "any devices" clause; (2) in the middle, the nominal signal levels at the earth's surface from the satellite DARS satellites (as determined by on-ground testing; and (3) a quarter of distance from the bottom of the Figure, the value (25 dBμV/m) Sirius proposed, more than a year ago, as the proper limit for out-of-band emissions into the SDARS band, to be applied to RF lights (and other Part 18 ISM device systems) operating in the 2.4 GHz band.

Figure 2: Fusion Lighting Lamp Emissions in the SDARS Band (data collected Nov. 3rd and February 28th)



Comparison of DOE installation to Tested Lamps.[3] For comparison purposes, the Fusion installation (noted as DOE above) that is currently deployed at the Department of Energy (DOE), in Washington, D.C. was also tested and is shown in the above chart. This DOE emits less RF out of band, as compared with other Fusion lamps tested, but is still significantly above the necessary level to avoid interference to SDARS satellite transmissions.

As an example, the first Fusion light tested (serial number 1227) radiated 112.2 dBμV/m at 3 meters in the 2450 MHz band (measured with a 1 MHz VBW). As can be seen in Figure 2 and in Table 1 (where the results are summarized), that same lamp radiated about 28 dB less energy into the satellite DARS band, with total out of band emissions at 3 meters of 84 dBμV/m. Thus, this Fusion lamp emits about 28 dB less energy out of band than in band (which we call "rolloff").[4]

In contrast, not all Fusion designs exhibit the same spectral signature. The Fusion lamp deployed at the Department of Energy radiates at 106.6 dBμV/m at 3 meters in the 2450 band (measured with a 1 MHz VBW). The in-band power of DOE installed light is almost 6 dB less than that of lamp 1227. However, the DOE installed lamp is a far better spectral neighbor: its out-of-band emissions at 3 meters are 51.6 dBμV/m. In other words, the Fusion lamp used at the Department of Energy installation sacrifices only 6 dB less energy in-band than a different Fusion lamp, but it reduces unwanted out-of-band emissions 27 dB more than other Fusion lamps, resulting in a total of 55 dB less unwanted power from Fusion lamps bleeding into the satellite DARS band.[5]

It is difficult to escape the obvious inference—that designs similar to that installed at the DOE could permit a to-be-designed Fusion sulfur lamp to meet Fusion's goals of high efficiency and at the same time not cause harmful interference to satellite DARS operations in nearby spectrum. This suggests that the lamp installed at the Department of Energy generates far better rolloff without a proportional reduction in efficiency: with a sacrifice of less than 6 dB of radiated power in band, the design permits a far better ratio of in-band energy to unwanted out-of-band energy: a rolloff of 55 dB. If Fusion can reduce harmful out-of-band interference by 27 dB by sacrificing only 6 dB of in band energy, a future lamp could be designed to provide additional rolloff and thus protection to adjacent channel services.

Discussion of Test Results

The Test Results Demonstrate that Some RF Lights Exceed FCC OOB Limits for "Any Device". As can be seen Figure 2, a number of RF lights emit OOB emissions in

[3] RF emission measurements on Fusion lighting system at the Department of Energy in Washington, D.C., on February 28, 2001. All measurements herein have been referenced to 3 meters from lighting source.
[4] The 28 dB figure was obtained by subtracting 84 dBμV/m from 112.2 dBμV/m.
[5] The 55 dB figure was obtained by subtracting 51.6 dBμV/m from 106.6 dBμV/m.

excess of even the most generous interpretation (applied to "Any Device") of the Commission's current limits. Although these OOB emission measurements were taken with a variety of VBW values, the FCC never has settled on the appropriate video bandwidth. Here, with a high-powered pulsed system, only a broader video bandwidth properly takes in account the normal interference between two systems, especially where the victim receiver is a broadcast service. In the tests performed, the narrower video bandwidth measurements converged to the 1 MHz measurement over time, suggesting that averaging could understate real world interference.[6] For all these reasons, measurements made with a 1 MHz video bandwidth, best depict the actual interference potential of RF lights to SDARS receivers.

Use of a 1 MHz VBW most accurately depicts the effects of OOB emissions on SDARS receivers (see section "Measured OOB Emissions" in the "Overview" section of this document). Based on our assumption of the waveform characteristic, sweep rate, rise time and duration, measurements made at 1 MHz VBW are likely to be more representative of the probable cause and effect to SDARS service delivery. Use of 30 kHz or 30 Hz VBW for such large bandwidth signals necessarily will depict an inaccurate representation of interference effects to SDARS.

In addition, the wide OOB emission bandwidth observed with the Spectrum Analyzer Resolution Bandwidth set to 1MHz, understates real-world interference issues since Sirius utilizes 4 MHz of authorized bandwidth for its SDARS receivers, while XM uses 2 MHz. Actual OOB emissions, when integrated over the victim satellite receiver bandwidth, could be 3(for XM) and 6 dB (for Sirius) higher than the present measurements indicate.

OOB Emissions by RF Lights at the Measured Levels Will Cause Harmful Interference to SDARS Receivers. As can be seen in Figure 2, the expected satellite DARS satellite signal strength on the earth's surface (referenced to 3 meters) is approximately 35 dBμV/m. The measured emissions from Fusion lamps vary, of course (depending on video bandwidth), but nearly all Fusion lamps tested would emit energy into the satellite DARS band at a level *stronger than the received signal from the satellite itself.* When a satellite DARS consumer radio receives interference at or greater than the desired carrier (*i.e.,* the carrier to interference ratio becomes negative), no reception is likely, and the service literally could go silent. If the customer is experiencing any signal degradation at that time (due, for example, to building blockage, foliage shielding, multipath fading—all well accounted for in the satellite DARS licensee's link budget), any remaining link margins could be driven toward zero, *making reception impossible.*

In any event, regardless of the VBW used for measurements, out-of-band energy from Fusion RF lights will be emitted well above the level of the received satellite signal

[6] In any event, averaging cannot, and should not, be applied in the absence of information about the pulse shape and duty cycle employed in the Fusion magnetron and power supply.

on the ground, and well above—50 dB above—the out-of-band restriction Sirius has urged the agency to apply to RF lights. This level, filed with the agency in a May 2000 engineering analysis in conjunction with Docket 98-42, was derived in view of the fact that satellites nearly always operate at margin and must be protected from higher power emissions from terrestrial services. Even coordination between satellite and terrestrial networks is complicated and time consuming. Sirius therefore suggested that the agency should protect consumer satellite DARS radios from excessive out-of-band emissions from any source, by ensuring that such unwanted signals be mitigated through filtering and shielding. Moreover, in order to protect the operations of a new consumer radio service, Sirius proposed interfering OOB signal should protect SDARS receivers to an interference-to-noise density ratio (I/N) of –10 dB.as shown in Figure 2.[7] This level is the highest interfering OOB signal level Sirius recommends in order to protect consumer satellite receivers.

This joint test report establishes conclusively that the exhibited out of band emissions from Fusion lights would render it difficult if not impossible to offer reliable satellite service in the S DARS band in the United States. The test results clearly indicate that Fusion's RF lights emit unwanted out-of-band energy in the satellite DARS band to such an extent that the OOB field strength of the RF lights vastly exceed not only the limit proposed by Sirius, but the SDARS satellite signal levels themselves as received on the earth's surface. As an example, Fusion light (serial number 1227) produced almost 50 dB more energy than the DARS satellite receive signal.[8] With an undesired signal that is considerably stronger than the desired signal, the SDARS service will experience severe degradation and outages—in other words, harmful interference.

To mitigate such interference, RF lighting systems could either be located geographically distant from SDARS receivers (impractical at best; impossible if RF lights are to be used in street lamp applications) or the OOB emissions from RF lights could be attenuated to ensure that the desired satellite signal strength is sufficient for clear reception. For this reason, RF lighting OOB emissions must be masked to a field strength of 25 dBμV/m at 3 meters. From the subsequent DOE lamp test, an out of band emission produces enough energy to require an SDARS receiver to be located 63 meters from the lamp to meet the 25 dBμV/m level. A similar example can be applied to Fusion's s/n 1227, where a distance of 1800 meters would be required. The appropriate field strength limits and rolloffs are described in Figure 3 below.

[7] 35dBμV/m- 25dBμV/m.

[8] 84 BμV/m- 35dBμV/m.

Figure 3: In Band and Out of Band Emissions and Rolloff For Two Different Fusion Light Designs (Measured at 3 meters)

	In Band (Main)	Out of Band	Rolloff (in band to out)
Fusion Sample (1227)	112.2 dBµV/m	84 dBµV/m	28 dB
DOE Installation	106.6 dBµV/m	51.6 dBµV/m	55 dB
FCC Limit (non RF Lts)[9]	Not Specified	70 dBµV/m	N/A
SDARS Requested Limit[10]	N/A	25 dBµV/m	N/A

The OOB emissions measured from the two lamps are instructive. The example suggests that it is possible that Fusion can make minor designs sacrifices in in-band radiated power (which should not significantly reduce efficiency) while limiting out-of-band emissions effectively, particularly in the satellite DARS band. This suggests that Fusion could re-design its lights to reduce interference to satellite DARS transmissions without significantly sacrificing illumination or efficiency.

Off-axis Discrimination Does Not Significantly Lower OOB Emissions. To provide information about the directivity of the RF light emissions, an attempt was made at measuring the relative radiation pattern of the emitter. By rotating the lamp circularly, several significant data points were logged and plotted below. As can be seen, the lamp's emission pattern closely resembles that of a wide beamwidth directional antenna, having a distinct main beam, side lobe suppression and front to back mirrored response. The low directivity does not significantly reduce the RF emission when moving away from the main beam (e.g., 45 and 60 degrees from main beam center); the energy has only gone down by 10 and 15 dB respectively.

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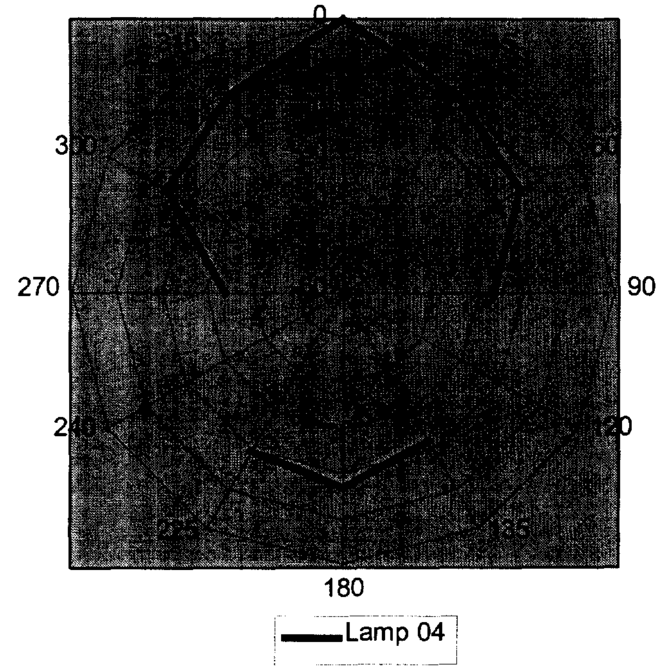
[9] The FCC Out of Band limitation was calculated for a 1000 watt sulfur lamp as follows,
Limit = 25 x√(1000w/500) = 35.36µV/m at 300m, 30.97dBµV/m at 300m, and 70dBµV/m at 3 meters.

[10] *See Ex Parte* Filing of Sirius Satellite Radio Inc. in ET Docket No. 98-42, dated May 25, 2000 for derivation of the SDARS limit.

Figure 4: Off-Axis Emissions From Fusion Light at 2345 MHz



As is shown in the figure below, the geometry of light poles varies between urban and rural environments. In urban areas, poles tend to be closer to the road and lower in height; in rural (highway) areas, they tend to be farther from the road and higher. Thus the average angle of arrival from an RF light on the side of a roadway to an SDARS receiver in an automobile ranges from 9 to 35 degrees.

Different angles of arrival result in different attenuation, but the polar plot above demonstrates that the off-axis attenuation will not be significant. In fact, typical emissions from an RF light mounted on a streetlight, pointed directly down, would be similar to the main beam of the antenna, with only 2 to 9 dB of attenuation, from antenna pattern discrimination, into the SDARS receiver. Moreover, this problem will be exacerbated as an RF lamp is further elevated or directed toward the roadway. The lack of off-axis attenuation for RF lights creates potentially larger areas of SDARS service degradation.

Figure 5: Streetlight Geometry and RF Light Rolloff

Distance from Base of Light to Center of Car (m)	Height of RF Light (m)	Angle of Arrival in Degrees	Approximate Rolloff (dB)
5	8.66	30.00	7
5	29.58	9.59	2
5.5	8.66	32.42	8
5.5	29.58	10.53	2
6	8.66	34.72	9
6	29.58	11.47	3

Conclusion

The November 2000 and February 2001 tests of Fusion RF light products have demonstrated that OOB emissions from these devices are unacceptably high and would exceed the SDARS received signal levels. In some cases, the OOB emissions are approximately 50 dB higher than the desired received DARS signal strength. There can be no dispute that such levels would cause harmful interference to the authorized satellite DARS radio service.

There are mitigation techniques that could reduce potential interference. However, despite requests from Sirius and XM, Fusion Lighting has still failed to provide complete pulsing and emission characteristics of the magnetrons that could be used to derive and analyze the actual waveform of its signal. Use of this information would have lead to more conclusive test data.[11] Moreover, the tests demonstrate that off-axis emissions from Fusion Lighting lamps are not greatly diminished away from the main beam.

To rectify the harmful interference potential presented by Fusion's RF products, these lamps should be modified to improve the lamps to be deployed and reduce the effects to SDARS receivers.[12] Moreover, the lamp design Fusion has employed at the DOE installation suggests that Fusion could design sulfur lights with greater OOB suppression (an additional rejection of 36 dB) with only minor reductions in efficiency (i.e. 15% efficiency reduction), thereby reducing OOB effects.[13] Additionally, filtering or other design changes (i.e., modifying the transmitted pulse characteristics) could be effected to greatly diminish OOB emissions from the RF lamps. Nonetheless, although the lamp installed at DOE appears to be the current 'best' case, the out of band emissions from that lamp still cause harmful interference to satellite DARS transmissions, and are well above Sirius's recommended limit.

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[11] From the results of these tests, the RF peak to average ratio observed was greater than 30 dB in the frequency domain. It is hard to determine the exact value of the peak emissions in the frequency domain, making it difficult to determine exactly the detrimental effects of peak emissions from RF lamps to SDARS receivers.

[12] The only other alternative to lowering OOB emissions is to increase the desired signal strength for the SDARS receive signal. To accomplish this, an enormous number of additional terrestrial repeaters would need to be deployed nationwide in any area with Fusion Lighting deployments. Such an option would complicate coordination with adjacent spectrum users. Such a massive implementation would require extra zoning approvals for the new terrestrial sites, extensive build outs of additional terrestrial repeater sites and extraordinary increased costs for the SDARS network.

[13] *See* Fusion Lighting Presentation submitted to FCC, "Efficiency vs. RF Shielding," August 1999.

CERTIFICATE OF SERVICE

I hereby certify that on this 4th day of May, 2001, I caused copies of the foregoing **Joint Supplemental Comments of Sirius Satellite Radio Inc. and XM Radio Inc. in ET Docket No. 98-42** to be mailed via first-class postage prepaid mail to the following:

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